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A SURVEY FORECAST OF NEW TECHNOLOGY IN UNIVERSITIES AND COLLEGES

by

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January 1972 585-72

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Abstract

A simplified Delphi questionnaire was mailed to technologists and tc a broad national sample of college and university faculty, librarians, and controllers. The responses yield predicted dates of adoption for various kinds of technologies. The technologies predicted are those thought most likely to have an impact on learning experiences within existing campuses, on the relative predominance of differing types of institutions, and on the structure of individual colleges and universities.

Acknowledgements

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This paper, however, reflects the views of the author and does not represent the official conclusions of the project.

I. INTRODUCTION

Institutions of higher learning in the U.S. are currently undergoing substantial stresses. New instructional technology has been viewed as offering hope for overcoming some of these stresses. There is thus considerable interest in forecasting the impact of this new technology on universities and colleges over the next fiteen years.

There exist a number of demonstration or experimental projects in computer-aided instruction, improved access to audio-visual materials, etc. Predictions have been made of advances in basic technology which will make even more sophisticated techniques possible. The potential of these new technologies have led some to visualize fairly dramatic changes in structure and style of institutions for higher education.[1] One may well ask, however, the likely rate of actual adoption of these various technologies in the typical college or university environment.

One promising approach for making such technological forecasts is the Delphi method of iterated forecasts from a panel of experts using controlled interaction among the panel between the iterations. However, research indicates that most, if not all, the benefits of the Delphi method can be obtained through predictions based on the sample median or mathematical mean of first round individual questionnaire predictions with no interaction.[2] In this paper, the latter technique is used to estimate adoption dates for a number of new technologies in colleges and universities. Early in 1971, four different questionnaires were mailed: one to technologists, one to

[1] See, for example, Eurich [1968], and the report of the Commission on Instructional Technology [1970].

[2] See Kaplan et al. [1950] and Dalkey [1969].

faculty, one to controllers, and one to librarians. The questionnaires for technologists and faculty partially overlapped. Their responses were aggregated within each of these four groups to obtain predicted dates of adoption. The following special analyses were also conducted:

1. estimation of dates of developments in underlying basic technologies;
2. principal components and factor analysis of underlying basic technologies predictions;
3. principal components and factor analysis of applied technologies predictions;
4. regression and non-parametric correlation of underlying basic technology predictions with applied technology adoption predictions;
5. analysis of differences in predictions between technologists and faculty;
6. summary of obstacles perceived by faculty to technological adoption;
7. analysis of differences in predictions among faculty by size of institution, by type of institution (public vs. private) and by academic field (business and edication vs. fine and liberal arts vs. science and engineering); and
8. analysis of differences in predictions among librarians and controllers by size of institution.

General conclusions are given at the end of the paper. Specific findings are distributed in each section.

Figure I, pages 4 through 8 , shows the questionnaire mailed to technologists. The mailing list was compiled from lists of those participating in various national conferences on new educational technology and on technological forecasting. The list includes many generally recognized experts in these fields.

There were ninety returns out of one hundred and forty-seven questionnaires mailed (61%).

In the questionnaire shown in Figure I each response was coded as follows:

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
Code:	1	2	3	4	5	6	7

Superimposed on the questionnaire is an "x" representing the median prediction.

Below the median code is the following information: the mean (M) and standard deviation (S) of the codes, a rough interpolation of the mean code in terms of dates (interpolated using Figure II), and the number of responses (N). For this purpose, "later or never" is regarded as equivalent to "by 2050".

For example, the display on item 1, Section A, indicates the median prediction was "by 1980", the mean code was 3.9, or about 1979, the standard deviation of the codes was 1.1, and there were 65 responses to the item.

The reader should note that the existence of the qualitative "later or never" code might make the interpolation of the mean code in terms of dates suspect. The median is not affected by this possible problem, but has less resolving power. Also, the reader should note that in calculating the mean roughly equal weights are given to the logarithms of the time

Figure I. Technologist Questionnaire

Introduction

This questionnaire has been distributed to those who have special knowledge of the technological potential for successful development of new technology likely to have an impact on institutions of higher education. The technologically-based estimates which will result will be combined and contrasted with user-based estimates prepared from other questionnaries.

Your forecasts should be based when practicable on your own first-hand experiences. Again, immediate impressions are usually nearly as good as long-drawn out consideration.

Mark an "X" in the time span column which you visualize as the most likely period during which an event will take place.

Example

If you think Event A will not occur until 1982, mark as follows:

Event A:

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
				X		

Section A: Forecast of Underlying Technological Development

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
1. The manufacturing cost of circuitry for computers will be reduced to less than $0.20 per 500-element chip	M= 3.9 (1979)			X			S= 1.1 N=65
2. The manufacturing cost of circuitry for computers will be reduced to less than $0.01 per 500 element chip	M = 5.3 (1995)				X		S= 1.3 N= 64
3. The cost of reliable interactive graphic terminals like IMLAC, ARDS, or Computic will be reduced to $1000	M= 3.9 (1979)			X			S=0.8 N= 75
4. As a result of laser or other technology, the cost of voice grade communication channels will be reduced to 1/10 of their 1971 cost	M = 4.7 (1986)				X		S= 1.0 N= 77

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
5. Computerized search for information on specialized topics will be more effective than typical human search	M=3.6 (1978)			X			S=1.8 N=89
6. Effective real-time optical memories for computers	M=4.4 (1983)			X			S=1.4 N=77
7. Effective compatibility of data files and programs across 50% of computers and operating systems in use to support instruction in a particular academic field	M=4.5 (1984)				X		S=1.4 N=88
8. Effective compatibility of data files and programs across 50% of computers and operating systems used to support research in a particular academic field	M=4.5 (1984)				X		S=1.4 N=86
9. Remote computer terminals will be installed in 10% of U.S. households	M=5.3 (1995)				X		S=0.9 N=89
10. Provision for hardcopy or video-tape reproduction of incoming TV signals will be installed in 10% of U.S. households	M=4.9 (1989)				X		S=0.8 N=90
11. Advances in printing or reproduction will reduce the manufacturing cost of an average text book to less than $0.25	M=5.9 (2008)					X	S=1.4 N=83
12. Inexpensive, safe drug products will be available which will double typical learning and memory abilities.	M=6.2 (2016)						X S=1.1 N=85

Section B. Forecast of User Applications

For each of the following forecasts please use as a frame of reference the period by which you visualize new technology used routinely within the typical institution of higher education.

1. Routine Audio-Visual Techniques--the classroom use of films, taped lectures shown on closed circuit television, or of listening laboratories, etc.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 2.8 (1974)		X				S = 1.5 N = 88

2. Programmed Instruction--the student uses a text or simple supplementary device which uses step-by-step feedback reinforcement techniques to progress through sequentially ordered, structured material. Good examples are programmed texts and self-study langauge audio tapes.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M=3.2 (1976)		X				S = 1.5 N = 89

3. Routine Computer-Assisted Instruction--the computer is used in the instructional process for either computerized programmed instruction or for drill and practice exercises.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 3.9 (1979)			X			S=1.2 N=90

4. Computer Simulation--the computer is used in simulation exercises involving student investigation of the properties of a "pseudo-reality" generated by a model of the phenomenon under study.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M=3.9 (1979)			X			S = 1.2 N=90

5. Advanced Computer-Assisted Instruction--the computer is used in a flexible, individualized way to support student exploration of a well-defined body of knowledge; this may include Socratic dialogue, tutorial exercises, and the ability to answer at least some unforeseen student questions.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 4.9 (1989)				X		S = 1.0 N=90

6. Computer-Managed Instruction--measures of the student's performance are monitored and analyzed by the computer; based on this the computer provides aid or direction to the student or teacher as to the most suitable packet of instructional material, such as film, programmed instruction, or live teacher, to be used next.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M=4.4 (1983)			X			S =1.1 N=90

7. Remote Classroom Broadcasting and Response--the use of remote television broadcasting from a central location to dispersed classrooms, with at least audio live response or questions from the students.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 3.9 (1979)			X			S= 1.3 N=89

8. Student-Initiated Access to Audio-Visual Recordings--the use of audio-video recordings in a technological environment sufficiently inexpensive and easy to use to allow individual student-initiated access to recorded lecture or demonstration material.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 3.9 (1979)			X			S= 1.1 N= 90

9. Computer Aided Course Design--the use of computers to record and analyze student responses to instructional packets in computer-assisted and computer managed instruction in order to provide information for the design of improvements in instructional material

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M=4.4 (1983)			X			S= 1.0 N= 87

10. Remote Library Browsing--the ability of users to "browse" through most library materials from a remote location with the aid of a computer and visual display terminal.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 5.2 (1993)				X		S=1.0 N=88

11. Man-Machine Research Support--the availability to the average researcher of remote time-shared computer consoles, computational support equal to the best available on an experimental basis in 1971.

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
M= 3.9 (1979)			X			S = 0.7 N =88

Section C:

Please rate how relatively confident you feel about your answers by marking an "X" in the appropriate block below:

des: 1	2	3	4	5
M = 2.5		X		S = 0.8 N=87

Less Confident		Moderately Confident		Very Confident

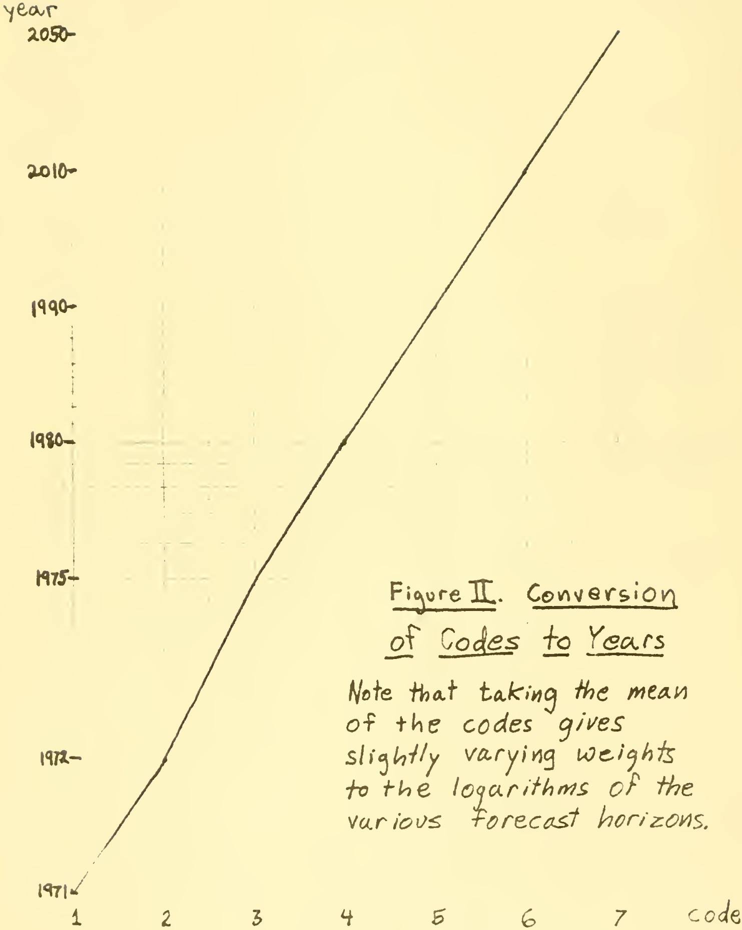

Figure II. Conversion of Codes to Years

Note that taking the mean of the codes gives slightly varying weights to the logarithms of the various forecast horizons.

intervals from the present to the predicted date. This is in accord with experimental evidence on the tendency toward logarithmic normal distributions of date responses to technological forecasting questions.

Technologists' Predictions of Underlying Technology

Some of the predictions here were rather more pessimistic than the author expected:

1. No breakthroughs in communication channel costs were generally foreseen before 1990;
2. Effective compatibility of data files and programs across 50% of computers and operating systems was not foreseen until about 1990;
3. Significant numbers of household computer terminals and video-tape or hardcopy facilities were not forecast until about 1990;
4. This group of technologists was pessimistic regarding the foreseeable impact of biological science on education.

Conclusions from Underlying Technology Forecasts

Given the delays to be expected in converting new basic technology into new products and the further delays in general adoption, the prospects appear negligible of radical revision of the organization of the campus toward individual home instruction before at least the turn of the century. This follows from the lack of breakthroughs in communications channels, printing, and household facilities. One can forecast remarkably increased availability of economical computer facilities, including much larger memories and inexpensive interactive display terminals, within perhaps fifteen years. These will clearly have potential impact within the typical college or university. However, the forecast of lack of compatibility among

computer files and programs means that there will not be radical homogenation in instruction via the computer across the various institutions.

The indication, then, is for continued existence of some kind of campus orientation providing economies of scale in instruction. This is not to say, however, that there may not be significant changes in on-campus instructional technology, and perhaps in the relative strengths of the different types of institutions that exist today. For example, profit-making enterprises are not hereby barred from a larger role.

Conclusions on Application Adoption Forecasts

The most surprising aspect of the forecasts of applied technology adoption by the technologists were the relatively early impacts foreseen on the typical college or university of many applications. Widespread use of the computer for routine CAI, simulation, and computer managed instruction were predicted by 1980. Advanced audio-visual systems (remote broadcasting with audio feedback, and student-initiated access to audio-video recordings) were also foreseen by 1980. These forecasts would imply widespread changes in teaching methods on the campus during the next fifteen years, obviously relying on the existing technology base.

One might note, however, that the technologists might be giving expression to a narrow, technological viewpoint.

Special Analyses of Technologist Questionnaire Responses

A principal components analysis of the responses on the various underlying technologies revealed that about thirty per cent of the normalized variance in the coded responses of all twelve items could be accounted for in terms of a single component.[3] This implies a mild technological "halo"

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[3] See Harman [1967] for an explanation of principal components analysis and factor analysis.

effect. That is, individual respondents tended to be somewhat optimistic or pessimistic across a wide range of items, rather than considering them completely independently. The correlations of the twelve items with this principal component are shown in Figure III.

When a varimax rotation of principal components of the basic technology predictions was done, however, the only strong local groupings of items were items 1, 2, and 3 (manuf. cost/chip <\$.01, manuf. cost/chip <\$.20, and interactive graphics terminal <\$1000) in one factor and items 7 and 8 (instructional computer compatibility and research computer compatibility) in another. This analysis indicates the lack of strong local interdependencies in the predictions for the other items. The significance to the reader is that whatever technological information he may have relevant to forecasting one item is not likely to be strongly relevant to the other items.

Similarly, a principal components analysis was made of the forecasts of applications of new technology (Section B items). This revealed a somewhat stronger "optimistic versus pessimistic" halo. About 37 per cent of the total normalized variance of the responses to the eleven applied items in Section B could be summarized in a single principal component. Figure IV gives the association of each item with this central theme. <u>All</u> of the items figured at least moderately in this component.

This relatively pervasive component of variation implies a somewhat greater commonality of attitude across the Section B items than across the Section A items for each individual. That is, he tends to be uniformly optimistic or pessimistic compared to the group of technologists as a whole.

Correlation Coefficient (Loading)	Item #	Label
.71	7	instructional computer compatibility
.70	2	manuf. cost of chip <$.01
.66	1	manuf. cost of chip <$.20
.61	10	household hardcopy
.61	11	printing cost text <$.25
.59	8	research computer compatibility
.57	9	household computer terminals
.55	3	interactive graphics terminal <$1000
not strongly related:		
.37	4	communications channels 1/10 1971 cost
.37	6	optical computer memories
.18	5	effective computer information search
.16	12	drugs for learning

Figure III

Loadings of Technologists' "Section A"

Items on their Principal Component

Correlation Coefficient (Loading)	Item #	Label
.74	3	routine CAI
.69	6	computer managed instruction
.64	7	remote classroom response
.64	4	computer simulation
.62	2	programmed instruction
.62	5	advanced CAI
.62	9	computer-aided course design
.60	8	student access to aud. vis.
.53	11	man-machine research support
.45	1	routine audio visual tech.
.44	10	remote library browsing

Figure IV

Loadings of Technologists "Section B"

Items on their Principal Component

Similarly, a varimax rotation of components indicated stronger local interdependencies among the Section B items than in Section A. Items 2 and 3 (programmed instruction and routine CAI) and also items 6, 4, and 9 (computer managed instruction, computer simulation, and computer aided course design) formed two strong clusters. There were also numerous weaker interdependencies. The first cluster may refer to opinions regarding the ease of structuring material. The second may refer to opinions regarding the general availability and acceptance of computers.

Figure V gives major loadings for the various rotated factors.

Finally, an analysis was made of the covariation in codes between the set of items predicting new developments in basic underlying technology and the set of items predicting the application listed in section B. The result was striking: although some coefficients were statistically significant, none were large enough to indicate an interdependency obviously important for the practical decision-maker! Both Pearson and Kendall-tau coefficients of correlation were investigated. Weak ($R^2 < .10$) associations were found via the Pearson coefficient between "graphical interactive displays <$1000" and Section B items 5, 9, and 11 (advanced CAI, computer-aided course design, and man-machine research support), and also between "communication channel cost <1/10 1971 cost" and item 10 (remote library browsing).

The conclusion to be drawn by the reader here is that the technologists as a group do not view the applications described in Section B as strongly dependent on the breakthroughs in basic technology described in the items of Section A.

Factor I	Correlation (Loading)	Item #	Label
	.91	2	programmed instruction
	.70	3	routine CAI
Factor II			
	.94	10	remote library browsing
Factor III			
	.92	8	student access to aud. vis.
Factor IV			
	.92	11	man-machine research support
	.44	9	computer-aided course design
Factor V			
	.84	7	remote classroom feedback
Factor VI			
	.83	6	computer managed instruction
	.63	4	computer simulation
	.57	9	computer-aided course design

Figure V

Loadings for Varimax Factors

of Section B Predictions

by Technologists

III. FACULTY QUESTIONNARIES

Figure VI, pages 18 through 26 , shows the questionnaire mailed to faculty. The mailing list was taken from The World of Learning, and represented stratification by size of institution, source of institutional support (private versus public) and academic field. It was aimed at gaining a very broad cross-section of faculty views in this country. In this, the faculty mailing list differed from that for technologists, which was drawn from a smaller group of nationally well-known activists in new technology. There were 152 returns out of 413 questionnaires mailed (37%) based on one mailing. Parenthetically, with the smaller sample sizes involved in the other questionnaires it was deemed important to increase the return through a follow-up mailing. Here, the first return was considered adequate because of the larger sample. One might suspect that faculty non-respondents might be on the average more conservative than respondents, but this was not investigated.

Again, each item for response was coded from left to right as follows:

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
Code:	1	2	3	4	5	6	7

Superimposed on each item of the questionnaire is an "x" representing the median prediction. Below is the following information: the mean of the individual response codes (M), followed by a date interpolated from Figure II in parentheses, the standard deviation of the codes (S), and the number of responses to the item (N).

Preliminary Conclusions Regarding Faculty Responses

The first overall conclusion one reaches quickly is that faculty predict routine adoption of most of the new technology as coming considerably

Figure VI. Faculty Questionnaires

Section A: Forecast of Instructional Technology Application

In this section, you are given brief descriptions of various devices and systems which might be used to supplement or supplant the existing teacher-student classroom instruction process. You are asked to roughly estimate the period during which adoption will occur in your general field of specialization, and in your institution. We ask that you distinguish between undergraduate and graduate adoption and between adoption as a secondary teaching support and adoption supplanting the traditional teacher.

Place an "x" in the time span column you visualize as most likely for adoption or other event to be predicted.

Example: If you estimate the event in 1986, mark as follows:

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
				X		

The areas of technology covered are audio-visual techniques, programmed instruction, computer-assisted instruction, computer-managed instruction, remote broadcasting, student-initiated access to audio-visual recordings, and advances in the technology of instructional improvement.

I. Routine Audio-Visual Techniques--the classroom use of films, taped lectures shown on closed-circuit television, or of listening laboratories, etc.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field, but not necessarily in my institution	X M= 2.1 (1972)						S=1.6 N=136
B. Used routinely in my institution for undergraduate courses in my field	M=3.0 (1975)		X				S=1.9 N=135
C. Used routinely in my institution for graduate courses in my field.	M=4.9 (1989)				X		S=2.2 N=135
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=5.6 (2000)						X S=1.8 N=132

II. Programmed Instruction--the student uses a text or simple supplementary device which uses step-by-step feedback reinforcement techniques to progress through sequentially ordered, structured material. Good examples are programmed texts and self-study language audio tapes.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field, but not necessarily in my institution	M= 3.1 (1975)		X				S=2.0 N=142
B. Used routinely in my institution for undergraduate courses in my field	M= 4.2 (1982)			X			S=2.0 N=133
C. Used routinely in my institution for graduate courses in my field	M= 6.0 (2010)						X S=1.5 N=129
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M= 6.1 (2013)						X S=1.4 N=130

III. Routine Computer-Assisted Instruction--the computer is used in the instructional process for either computerized programmed instruction or for drill and practice exercises.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field, but not necessarily in my institution	M= 3.5 (1977)		X				S=2.0 N=140
B. Used routinely in my institution for undergraduate courses in my field	M= 4.2 (1982)			X			S= 1.9 N=134
C. Used routinely in my institution for graduate courses in my field	M= 5.1 (1992)				X		S= 2.1 N=132
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.4 (2023)						X S=1.1 N=131

IV. Computer Simulation--the computer is used in simulation exercises involving student investigation of the properties of a "pseudo-reality" generated by a model of the phenomenon under study.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M= 3.8 (1979)			X			S= 2.1 N=139
B. Used routinely in my institution for undergraduate courses in my field	M= 4.4 (1983)			X			S= 2.1 N=133
C. Used routinely in my institution for graduate courses in my field	M= 4.6 (1985)				X		S= 2.2 N= 133
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.5 (2027)						X S= 1.3 N=129

V. Advanced Computer Assisted Instruction--the computer is used in a flexible, individualized way to support student exploration of a well-defined body of knowledge; this may include Socratic dialogue, tutorial exercises, and the ability to answer at least some unforseen student questions.

	Currently	By 1972	By 1975	By 1980	By 1990	By 201C	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M=4.5 (1984)			X			S=1.7 N=140
B. Used routinely in my institution for undergraduate courses in my field	M=5.1 (1992)				X		S=1.5 N=130
C. Used routinely in my institution for graduate courses in my field	M=5.4 (1996)					X	S=1.8 N=128
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.5 (2027)						X S=0.9 N=127

VI. Computer-Managed Instruction--measures of the student's performance are monitored and analyzed by the computer; based on this the computer provides aid or direction to the student or teacher as to the most suitable packet of instructional material, such as film, programmed instruction, or live teacher, to be used next.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M=4.7 (1986)				X		S=1.7 N=139
B. Used routinely in my institution for undergraduate courses in my field	M=5.3 (1995)				X		S=1.4 N=129
C. Used routinely in my institution for graduate courses in my field	M=5.8 (2005)						X S=1.4 N=129
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.5 (2027)						X S=1.0 N=129

VII. Remote Classroom Broadcasting and Response--the use of remote television broadcasting from a central location to dispersed classrooms, with at least audio live response or questions from the students.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M = 2.9 (1974)		X				S=1.9 N=143
B. Used routinely in my institution for undergraduate courses in my field	M=4.5 (1984)			X			S = 1.8 N=130
C. Used routinely in my institution for graduate courses in my field	M= 5.4 (1996)						X S = 2.0 N = 132
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.0 (2010)						X S = 1.6 N = 132

VIII. Student-initiated Access to Audio-visual Recordings--the use of audio-video recordings in a technological environment sufficiently inexpensive and easy to use to allow individual student-initiated access to recorded lecture or demonstration material.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M=3.0 (1975)		X				S=1.5 N=140
B. Used routinely in my institution for undergraduate courses in my field	M= 3.8 (1979)			X			S=1.6 N=133
C. Used routinely in my institution for graduate courses in my field	M= 4.7 (1986)			X			S = 1.9 N= 134
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M=6.2 (2016)						X S = 1.5 N=131

IX. Computer-Aided Course Design--the use of computers to record and analyze student responses to instructional packets in computer-assisted and computer-managed instruction in order to provide information for the design of improvements in the instructional material.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Fairly widely available for some courses in my field but not necessarily in my institution	M=4.4 (1983)			X			S=1.6 N=137
B. Used routinely in my institution for undergraduate courses in my field	M = 5.1 (1992)				X		S = 1.5 N=128
C. Used routinely in my institution for graduate courses in my field	M = 5.7 (2003)					X	S = 1.5 N = 127
D. Has largely supplanted the traditional live teacher classroom instruction in some courses taught by my department	M = 6.6 (2031)						X S=0.9 N=124

Section B: Constraints on the Adoption of New Instructional Technology

Please use the following codes to rate the probable significance of different factors such as funding, attitudes, etc. as obstacles restraining the adoption of new technology in your institution.

Code	Constraint
T	Effectiveness of technology for inducing learning
$	Availability of funds to pay for new technology
F	Attitude of faculty
S	Attitude of students
A	Attitude of administration

Now, use these codes to rate the obstacles facing each group of technologies. For example, if you predicted adoption of audio-visuals in 1975, rate these factors in terms of importance in delaying adoption till that date.

Example

Not a real obstacle	A, T		$, S	F		Severe obstacle

Again, your first reaction is probably most useful, so don't spend more than ten minutes on this part of the questionnaire.

	Not a real obstacle				A severe obstacle
I. Routine Audio-Visual Techniques					
II. Programmed Instruction					
III. Routine Computer Assisted Instruction					
IV. Computer Simulation					
V. Advanced Computer-Aided Instruction					
VI. Computer-Managed Instruction					
VII. Remote Classroom Broadcasting and Response					
VIII. Student-initiated Access to Audio-Visual Recordings					
IX. Computer-Aided Course Design					
	Not a real obstacle				A severe obstacle

ction C: Please indicate when relative to the adoption of new technologies in your dergraduate courses you expect the technologies will be used routinely in graduate urses in your discipline.

1	2	3	4	5
				X
re than years fore they e used in dergraduate urses	2 - 5 years before	W/in the same year	2 - 5 years later	More than 5 years after they are used in undergraduate courses

ction D: Please rate how relatively confident you feel about your answers by rking an "x" in the appropriate block below:

1	2	3	4	5
		X		
Less Confident		Moderately Confident		Very Confident

later than do technologists. See Figure VII for a comparison. However, this overall comparison is somewhat misleading, as we will see later.

The second striking point is the sharp difference in timing between different degrees of impact. For example, the predicted lag from "fairly wide availability" in one's academic field to routine use in one's own institution for undergraduates ranges from three or four years for items 1 and 8 (routine audio-visual techniques and student-initiated access to audio-visual recordings) to nine or ten years for items 6, 7, and 9 (computer-managed instruction, remote classroom broadcasting and response, and computer-aided course design). The further lag from predicted use for undergraduates to use for graduates ranges from two to four years for computer simulation and advanced CAI through over a decade for routine audio-visual techniques, remote classroom broadcasting, and computer aided course design, to at least thirty years for programmed instruction.

Finally, faculty very strongly predict that the traditional live teacher classroom instruction will not be supplanted in even some courses taught by their own departments before 2000. No doubt this latter prediction incorporates some emotion as well as logic, but it is clearly significant.

According to mean faculty predictions, by 1980 routine undergraduate use will come for only routine audio-visual techniques and student-initiated access to audio-visual recordings. A few years later will come programmed instruction, routine CAI, computer simulation, and remote classroom broadcasting and response. Advanced CAI, computer-managed instruction, and computer-aided course design are not predicted until after 1990.

Generally summarizing, only those technologies well within the current state of the art are foreseen by faculty as destined for

Item	Label	Faculty Predict. of Availability	Technologist Prediction Routine Use	Faculty Prediction Routine Use For Undergrad
1.	routine audio-visual tech.	1972	1974	1975
2.	programmed instruction	1975	1976	1982*
3.	routine CAI	1977	1979	1982
4.	computer simulation	1979	1979	1983
5.	advanced CAI	1984	1989	1992
6.	computer managed instr.	1986	1983	1995*
7.	remote classroom feedback	1974	1979	1984*
8.	student-initiated access a/v	1975	1979	1979
9.	computer-aided course design	1983	1983	1992*

*Difference in means for routine use is significant at 0.01 level according to large-sample test (two-tailed).

Figure VII

Faculty Mean Predictions of Availability and Routine Undergraduate Use, Technologists' Mean Predictions of Routine Use

adoption within the next fifteen years. However, one cannot infer a lack of change in instruction within colleges and universities. Even technological advances on the order of student-initiated access to audio-visual recordings or routine CAI could produce some important changes in institutional style and structure as well as in the relative roles played by different types of institutions. Also, as we will see shortly, there are dramatic differences by academic field in the faculty predictions.

Special Analyses of Faculty Questionnaire Responses

An analysis was done comparing the prediction responses of faculty by size of institution.[4] Figure VIII gives details. In general, faculty of the larger schools predicted adoption of new instructional technology sooner, but the inidividual item differences were small.

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[4] The analyses by size and for public vs. private were done by Mr. Joseph R. Matson based on about ninety per cent of the returns.

Item	Degree of Impact	Institutions < 10,000	Institutions > 10,000
1. routine audio-visual	A	1973	1972
	B	1976	1974
	C	1996	1986
	D	2010	1996
2. programmed instr.	A	1974	1976
	B	1984	1981
	C	2013	2008
	D	2013	2013
3. routine CAI	A	1977	1978
	B	1982	1982
	C	2000	1987 *
	D	2023	2023
4. computer simulation	A	1979	1979
	B	1986	1982
	C	1990	1983
	D	2031	2023
5. advanced CAI	A	1983	1984
	B	1992	1990
	C	2003	1993
	D	2031	2027
6. computer-managed instr.	A	1985	1986
	B	1996	1993
	C	2010	2003
	D	2035	2023
7. remote classroom response	A	1974	1974
	B	1987	1982
	C	2005	1993
	D	2016	2008
8. student-initiated access to audio-vis.	A	1976	1974
	B	1981	1978
	C	1990	1984
	D	2019	2016
9. computer-aided course design	A	1989	1982 *
	B	1996	1989
	C	2013	1998 *
	D	2031	2031

*Differences in means significant at the 0.02 level by two-tailed large-sample test.
** A - available, B - routine use for undergraduates, C - routine use for graduates, D - supplanted teacher.

Figure VII. Differences in Mean Codes of Faculty Responses by Size of Institution

An analysis was also made of faculty responses from private institutions versus public institutions. At least at the broad aggregate level, no significant differences were found.

Finally, faculty responses were analyzed on a sample basis for differences by academic field. Three broad groups were distinguished, as outlined in Figure IX. Differences among these three groups were investigated for each technological item and for each degree of impact. As Figure X indicates, there were highly significant differences. Much or most of the greater pessimism shown by faculty as opposed to technologists arises from within the liberal and fine arts fields.

Apparently faculty in the liberal and fine arts fields are considerably different in their prediction of the adoption of new technologies than are faculty in the sciences and in business and education. It is interesting to note a much greater degree of differences between academic fields for computer-assisted instruction (CAI) than for student-initiated access to audio-visual recordings. Both technologies tend toward taking the student out of the classroom, thus possibly threatening some change for all faculty. However, CAI implies a fairly drastic structuring of the subject material as well. This might well be more difficult to carry out in the liberal and fine arts fields.

Liberal and Fine Arts

English

History

Geography

Philosophy

Music

Foreign Languages

Fine Arts

Arts and Sciences

Business and Education

Accounting

Business Administration

Education

Engineering and Science

Engineering

Physics

Chemistry

Mathematics

Social Sciences

Figure IX

Categorization of Academic Fields of

Respondents by Broad Groups

Item	Degree** of Impact	Technol.	Eng.Sci.	Bus.Ed.	Lib & Fine Arts
1. routine audio-visual	A		1972	1972	1973
	B	1974	1974	1975	1975
	C		1992	1981	1998
	D		1996	1998	2008
2. programmed instr.	A		1974	1975	1977
	B	1976	1981	1980	1984
	C		2010	1995	2023
	D		2010	2010	2016
3. routine CAI	A		1975	1976	1982*
	B	1979	1978	1978	1990*
	C		1987	1982	2013*
	D		2019	2023	2027
4. computer simulation	A		1975	1974	1993*
	B	1979	1978	1979	2000*
	C		1981	1979	2008*
	D		2019	2023	2031
5. advanced CAI	A		1980	1981	1992*
	B	1989	1987	1985	2000*
	C		1996	1989	2005
	D		2035	2019	2031
6. computer-managed instr.	A		1984	1982	1993
	B	1983	1992	1987	2003
	C		2005	1990	2023
	D		2031	2023	2031
7. remote classroom response	A		1974	1972	1977
	B	1979	1983	1980	1987
	C		1990	1993	2008
	D		2013	2000	2016
8. student-initiated access to audio-visual	A		1974	1973	1977*
	B	1979	1977	1978	1982
	C		1987	1980	1992
	D		2016	2016	2016
9. computer-aided course design	A		1980	1982	1989*
	B	1983	1986	1985	2005*
	C		1996	1993	2019*
	D		2031	2031	2035

*Difference in means between arts vs. engineering and science is significant at the 0.01 level by two-tailed large sample test.

**A - available, B - routine use for undergraduates, C - routine use for graduates, D - supplanted teacher in some courses.

Figure X. Differences in Mean Code Responses by Academic Field

Section B of the faculty questionnaire (See Figure VI) asked for ratings as to the relative difficulty imposed on adoption of new technology by constraints of technology, effectiveness, funding, faculty attitudes, student attitudes, and administration attitudes. The responses strongly indicated that faculty generally rank these constraints as follows:

1. funding
2. faculty attitudes
3. technology
4. student attitudes
5. administration attitudes

In most cases faculty attitudes were perceived as a greater obstacle to adoption than was lack of technological effectiveness.

IV. LIBRARIAN QUESTIONNAIRES

The questionnaire sent to college and university librarians is shown as Figure XI, pages 36 to 38. Out of 164 mailed, 122 (74%) were returned. Again, the responses were coded as follows:

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
Code:	1	2	3	4	5	6	7

As for the previous questionnaires, the median (x), mean (M), standard deviation (S), and number responding (N) are indicated on the face of the questionnaire for each item.

The respondents were generally the heads of the libraries at their respective institutions.

Item III-A (remote browsing) of this questionnaire may be matched with item 10 of Section B of the technologists' questionnaire. For this item, the mean librarian code is 5.8 (2005) and the mean technologists' code is 5.2 (1993). This conforms to similar differences in optimism between technologists and faculty, especially liberal arts faculty.

The earliest adoption of the new technologies listed were for the automation of library purchasing and circulation management (1979) and the routine receipt by users of listings of new publications matched to their special interests (1982).

If the librarians are generally correct, no major changes in library technology may be expected for nearly another decade in the typical college library.

Figure XI. Librarian Questionnaires

Introduction

This is a very short questionnaire aimed at getting a broadly-based estimate of dates of introduction of important new technology in libraries.

Please answer each question from the frame of reference of your own institution. Mark an "x" in the time span column which you visualize as the most likely period during which an event will take place.

Example

If you think Event A will not occur until 1982, mark as follows:

Event A:

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
				X		

I. Miniaturization and Copying

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. More than 50% of library's new periodicals will be stored on microfilm, microfiche, etc.	M=4.9 (1989)				X		S=1.5 N=120
B. More than 50% of library's new books will be stored on microfilm microfiche, etc.	M=6.3 (2019)						X S=0.9 N=121
C. Library users will receive copies (microfiche or xerox) for a charge less than 50% of the 1971 price for original materials	M=4.9 (1989)				X		S=1.6 N=118

II. Computer Applications

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Library purchasing and circulation management will be substantially automated	M=3.9 (1979)			X			S=1.2 N=121
B. Library users will routinely receive listings of new publications matched to their special interests	M=4.2 (1982)			X			S=1.5 N=120
C. Library users routinely request computerized retrieval of library materials relevant to a particular topic, author or title	M=4.9 (1989)				X		S=1.2 N=121
D. Regional catalogues of materials available will be accessible to individual university libraries through remote computer consoles	M=4.7 (1986)				X		S=1.2 N=121

III. Advanced Systems

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. Library users will be able to "browse" through most library materials from a remote location with the aid of a computer and visual display terminal	M=5.8 (2005)					X	S=1.2 N=121
B. Effective research libraries will be operated as remote terminal branches of large central libraries where the materials are actually stored	M=5.5 (1998)					X	S=1.2 N=120

IV. Please rate how relatively confident you feel about your answers by marking an "X" in the appropriate block below:

		X		

Less Confident | Moderately Confident | Very Confident

By the late 1980's, however, more far-reaching changes are predicted. These include microfiche periodicals, much cheaper copy service, computerized retrieval, and regional catalogues. They will make it possible for even small, regional institutions to have access to good research libraries. This will not necessarily produce homogenization of research quality among institutions, however, because by this time the leading research institutions may have further developed their own library capabilities.

Analysis of Librarian Responses by Institutional Size

These data were analyzed by splitting the sample by size of student enrollment of the institution.[5]

Librarians of universities with greater than 10,000 student population were not uniformly more optimistic. However, for the two items where there were highly significant differences, the librarians from the larger universities predicted adoption by 1976 as opposed to 1982, and for regional catalogues they predicted adoption by 1983 as opposed to 1987.

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[5] Mr. Joseph R. Matson performed this analysis.

V. CONTROLLER QUESTIONNAIRES

The questionnaire sent to college and university controllers and other chief business officers is shown as Figure XII, pages 41 to 43. Out of 174 mailed, 98 (56%) were returned. Again, the responses were coded as follows:

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
Code:	1	2	3	4	5	6	7

Again, the median (x), mean (M), standard deviation (S), and number responding (N) are indicated on the face of the questionnaire for each item.

The respondents were generally senior members of their institution concerned with financial, accounting, and budgetary matters. Many were treasurers or business managers rather than controllers *per se*.

Interestingly, these senior administrators predicted early adoption by their own institution of computerized budgeting and planning technology. At least rudimentary simulation models of the university were expected by the end of the decade for the typical institution.

The controllers at large institutions (student body > 10,000) predicted from one to four years earlier adoption for every item then did the remainder of the sample.

Figure XII. Controller Questionnaires

Introduction

This is a very short questionnaire sent only to administrators of institutions of higher education. The main purpose here is to get a better estimate of dates of introduction of new computer technology for aiding the administrative process.

Please answer each question from the frame of reference of your institution. Mark an "x" in the time span column which you visualize as the most likely period during which an event will take place.

If you think Event A will not occur until 1982, mark as follows:

Event A:

Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
				X		

I. Short-term Budgeting and Control--the use of the computer as an aid to financial budgeting, reporting, and performance analysis.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. At least 75% of the data base for budgeting will be computerized	M=2.3 (1973)	X					S=1.4 N=98
B. Computer-based monthly reports by major expenditure category allowing comparison with budget figures	X M=2.1 (1972)						S=1.3 N=98

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
C. Computer-based annual reports allowing some control over utilization of resources (faculty workloads, utilization of space, etc.) and analysis of performance	M=2.9 (1974)		X				S=1.2 N=97
D. Routine computer analysis of actual vs. budgeted variances for statistical significance and causal relationships	M=2.9 (1974)		X				S=1.3 N=96
E. Computer-based scheduling of university resources: classrooms, physical plant, etc.	M=3.1 (1975)		X				S=1.4 N=96

I. Long-Term Planning-- the use of computer to investigate long-run (longer than one year) trends in key variables and to forecast the results of major alternative courses of action.

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
A. The data base necessary for computerized long-term planning of funding is 75% complete	M=3.4 (1977)		X				S=1.2 N=96

	Currently	By 1972	By 1975	By 1980	By 1990	By 2010	Later or Never
B. The data base necessary for computerized long term planning of faculty requirements is 75% complete	M=3.3 (1976)		X				S=1.4 N=96
C. The data base necessary for computerized long term planning of physical facilities is 75% complete	M=3.5 (1977)		X				S=1.5 N=96
D. The data base necessary for computerized long term planning for student enrollment is 75% complete	M=3.1 (1975)		X				S=1.5 N=95
E. Computer-based models of the university used in evaluating alternatives and asking "what if" questions regarding funds, physical facilities, students and faculty.	M=3.9 (1979)			X			S=1.3 N=95

II. Please rate how relatively confident you feel about your answers by marking an "X" in the appropriate block below:

		X		

Less Confident — Moderately Confident — Very Confident

VI. CONCLUSION

A simplified Delphi questionnaire was mailed to technologists and to a broad national sample of college and university faculty, librarians, and controllers. The responses yield predicted dates of the adoption of various kinds of new technology thought most likely to have an impact on the structure of individual institutions and on the relative predominance of various types of such institutions, as well as on learning experiences on existing campuses. These predictions may be found in Figures I, VI, XI, and XII. While it is not the intent of the author to speculate here on the implications of these predictions, certain observations are obvious:

1. Technologists do not rely on an expectation of major breakthroughs in basic technology in their predictions of the adoption of new educational devices.

2. The fundamental structure of campus-oriented higher education is unlikely to change during the next twenty-five years as a result of new technology.

3. However, adoptions in the area of routine computer-assisted instruction and student-initiated access to audio-visual materials are likely to markedly affect the style of undergraduate instruction during the next decade. As seen by faculty, the greatest obstacles to adoption of new technology are funding and faculty attitudes.

4. There is noticeably more optimism by technologists than by faculty in these matters. However, most of this difference is accounted for by faculty in the liberal and fine arts, who are much more pessimistic than faculty in the sciences and professional fields.

5. Radical innovations in libraries may be relatively slow in adoption. The only significant changes predicted during the next decade are purchasing and circulation automation at the larger universities.

6. College administrators predict rapid computerization of fiscal planning and control.

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